4.6 Solvent Degreasing

4.6.1 General[1,2]

Solvent degreasing (or solvent cleaning) is the physical process of using organic solvents to remove grease, fats, oils, wax or soil from various metal, glass, or plastic items. The types of equipment used in this method are categorized as cold cleaners, open top vapor degreasers, or conveyorized degreasers. Nonaqueous solvents such as petroleum distillates, chlorinated hydrocarbons, ketones, and alcohols are used. Solvent selection is based on the solubility of the substance to be removed and on the toxicity, flammability, flash point, evaporation rate, boiling point, cost, and several other properties of the solvent.

The metalworking industries are the major users of solvent degreasing, i. e., automotive, electronics, plumbing, aircraft, refrigeration, and business machine industries. Solvent cleaning is also used in industries such as printing, chemicals, plastics, rubber, textiles, glass, paper, and electric power. Most repair stations for transportation vehicles and electric tools use solvent cleaning at least part of the time. Many industries use water-based alkaline wash systems for degreasing, and since these systems emit no solvent vapors to the atmosphere, they are not included in this discussion.

4.6.1.1 Cold Cleaners -

The 2 basic types of cold cleaners are maintenance and manufacturing. Cold cleaners are batch loaded, nonboiling solvent degreasers, usually providing the simplest and least expensive method of metal cleaning. Maintenance cold cleaners are smaller, more numerous, and generally use petroleum solvents as mineral spirits (petroleum distillates and Stoddard solvents). Manufacturing cold cleaners use a wide variety of solvents, which perform more specialized and higher quality cleaning with about twice the average emission rate of maintenance cold cleaners. Some cold cleaners can serve both purposes.

Cold cleaner operations include spraying, brushing, flushing, and immersion. In a typical maintenance cleaner (Figure 4.6-1), dirty parts are cleaned manually by spraying and then soaking in the tank. After cleaning, the parts are either suspended over the tank to drain or are placed on an external rack that routes the drained solvent back into the cleaner. The cover is intended to be closed whenever parts are not being handled in the cleaner. Typical manufacturing cold cleaners vary widely in design, but there are 2 basic tank designs: the simple spray sink and the dip tank. Of these, the dip tank provides more thorough cleaning through immersion, and often is made to improve cleaning efficiency by agitation. Small cold cleaning operations may be numerous in urban areas. However, because of the small quantity of emissions from each operation, the large number of individual sources within an urban area, and the application of small cold cleaning to industrial uses not directly associated with degreasing, it is difficult to identify individual small cold cleaning operations. For these reasons, factors are provided in Table 4.6-1 to estimate emissions from small cold cleaning operations over large urban geographical areas. Factors in Table 4.6-1 are for nonmethane VOC and include 25 percent 1,1,1 trichloroethane, methylene chloride, and trichlorotrifluoroethane.

4.6.1.2 Open-Top Vapor Systems -

Open-top vapor degreasers are batch loaded boiling degreasers that clean with condensation of hot solvent vapor on colder metal parts. Vapor degreasing uses halogenated solvents (usually

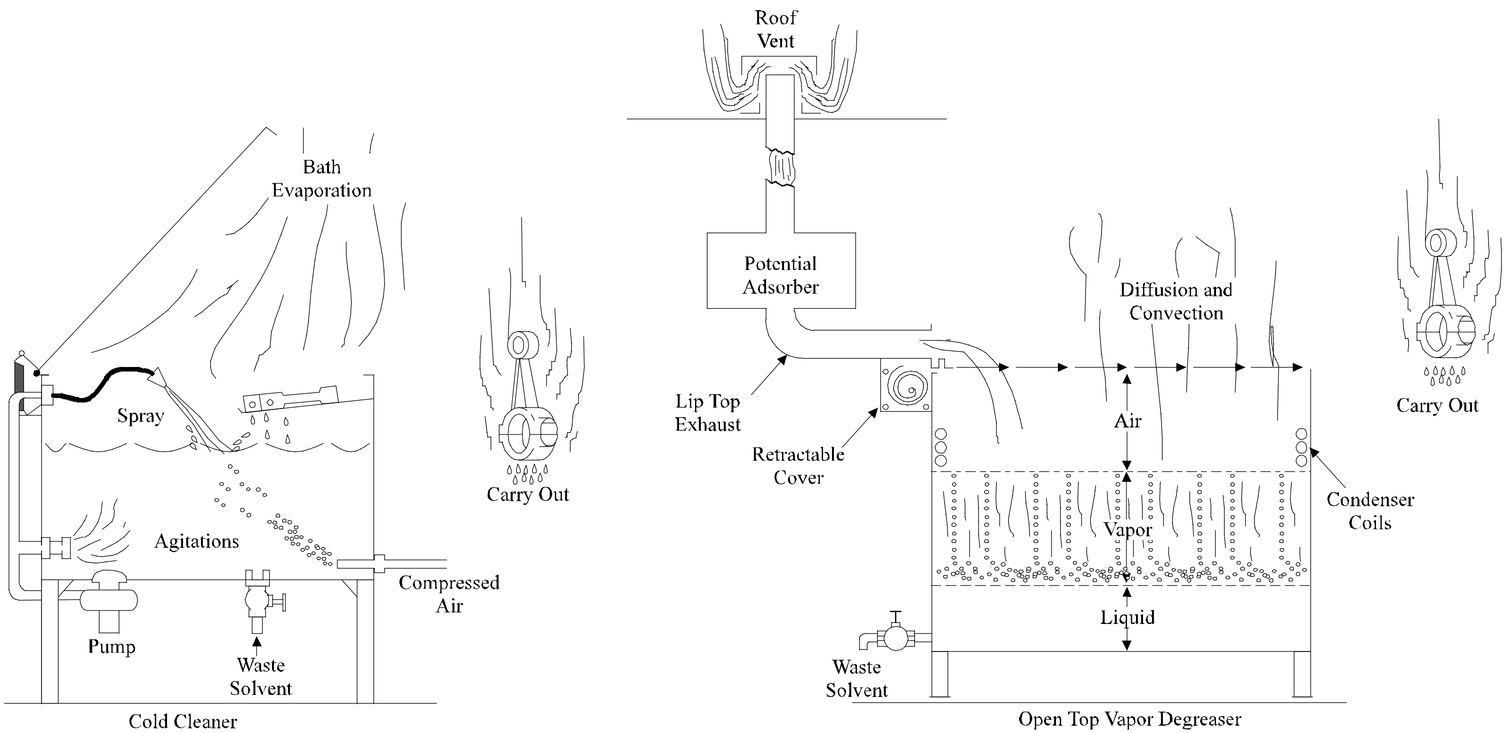

Figure 4.6-1. Degreaser emissions points.

Table 4.6-1 (Metric And English Units). NONMETHANE VOC EMISSIONS FROM SMALL COLD CLEANING DEGREASING OPERATIONS[a]

EMISSION FACTOR RATING: C

Operating Period	Per Capita Emission Factor
Annual	1.8 kg 4.0 lb
Daily[b]	5.8 g 0.013 lb

[a] Reference 3.
[b] Assumes a 6-day operating week (313 days/yr).

perchloroethylene, trichloroethylene, or 1,1,1-trichloroethane), because they are not flammable and their vapors are much heavier than air.

A typical vapor degreaser (Figure 4.6-1) is a sump containing a heater that boils the solvent to generate vapors. The height of these pure vapors is controlled by condenser coils and/or a water jacket encircling the device. Solvent and moisture condensed on the coils are directed to a water separator, where the heavier solvent is drawn off the bottom and is returned to the vapor degreaser. A "freeboard" extends above the top of the vapor zone to minimize vapor escape. Parts to be cleaned are immersed in the vapor zone, and condensation continues until they are heated to the vapor temperature. Residual liquid solvent on the parts rapidly evaporates as they are slowly removed from the vapor zone. Lip mounted exhaust systems carry solvent vapors away from operating personnel. Cleaning action is often increased by spraying the parts with solvent below the vapor level or by immersing them in the liquid solvent bath. Nearly all vapor degreasers are equipped with a water separator which allows the solvent to flow back into the degreaser.

Emission rates are usually estimated from solvent consumption data for the particular degreasing operation under consideration. Solvents are often purchased specifically for use in degreasing and are not used in any other plant operations. In these cases, purchase records provide the necessary information, and an emission factor of 1000 kg of volatile organic emissions per Mg (2000 lb/ton) of solvent purchased can be applied, based on the assumption that all solvent purchased is eventually emitted. When information on solvent consumption is not available, emission rates can be estimated if the number and type of degreasing units are known. The factors in Table 4.6-2 are based on the number of degreasers and emissions produced nationwide and may be considerably in error when applied to a particular unit.

The expected effectiveness of various control devices and procedures is listed in Table 4.6-3. As a first approximation, this efficiency can be applied without regard for the specific solvent being used. However, efficiencies are generally higher for more volatile solvents. These solvents also result in higher emission rates than those computed from the "average" factors listed in Table 4.6-2.

4.6.1.3 Conveyorized Degreasers -

Conveyorized degreasers may operate with either cold or vaporized solvent, but they merit separate consideration because they are continuously loaded and are almost always hooded or enclosed. About 85 percent are vapor types, and 15 percent are nonboiling.

Table 4.6-2 (Metric And English Units). SOLVENT LOSS EMISSION FACTORS FOR DEGREASING OPERATIONS

EMISSION FACTOR RATING: C

Type Of Degreasing	Activity Measure	Uncontrolled Organic Emission Factor[a]	
All[b]	Solvent consumed	1,000 kg/Mg	2,000 lb/ton
Cold cleaner			
Entire unit[c]	Units in operation	0.30 Mg/yr/unit	0.33 tons/yr/unit
Waste solvent loss		0.165 Mg/yr/unit	0.18 tons/yr/unit
Solvent carryout		0.075 Mg/yr/unit	0.08 tons/yr/unit
Bath and spray evaporation		0.06 Mg/yr/unit	0.07 tons/yr/unit
Entire unit	Surface area and duty cycle[d]	0.4 kg/hr/m^2	0.08 lb/hr/ft^2
Open top vapor			
Entire unit	Units in operation	9.5 Mg/yr/unit	10.5 ton/yr/unit
Entire unit	Surface area and duty cycle[e]	0.7 kg/hr/m^2	0.15 lb/hr/ft^2
Conveyorized, vapor			
Entire unit	Units in operation	24 Mg/yr/unit	26 tons/yr/unit
Conveyorized, nonboiling			
Entire unit	Units in operation	47 Mg/yr/unit	52 tons/yr/unit

[a] 100% Nonmethane VOC.
[b] Solvent consumption data will provide much more accurate emission estimates than any of the other factors presented.
[c] Emissions generally would be higher for manufacturing units and lower for maintenance units.
[d] Reference 4, Appendix C-6. For trichloroethane degreaser.
[e] For trichloroethane degreaser. Does not include waste solvent losses.

4.6.2 Emissions And Controls[1-3]

Emissions from cold cleaners occur through: (1) waste solvent evaporation, (2) solvent carryout (evaporation from wet parts), (3) solvent bath evaporation, (4) spray evaporation, and (5) agitation (Figure 4.6-1). Waste solvent loss, cold cleaning's greatest emission source, can be reduced through distillation and transport of waste solvent to special incineration plants. Draining cleaned parts for at least 15 seconds reduces carryout emissions. Bath evaporation can be controlled by using a cover regularly, by allowing an adequate freeboard height, and by avoiding excessive drafts in the workshop. If the solvent used is insoluble in and heavier than water, a layer of water 5 to 10 centimeters (2 to 4 inches) thick covering the solvent can also reduce bath evaporation. This is known as a "water cover". Spraying at low pressure also helps to reduce solvent loss from this part of the process. Agitation emissions can be controlled by using a cover, by agitating no longer than necessary, and by avoiding the use of agitation with low volatility solvents. Emissions of low volatility solvents increase significantly with agitation. However, contrary to what one might expect, agitation causes only a small increase in emissions of high volatility solvents. Solvent type is the variable that most affects cold cleaner emission rates, particularly the volatility at operating temperatures.

Table 4.6-3. PROJECTED EMISSION REDUCTION FACTORS FOR SOLVENT DEGREASING[a]

System	Cold Cleaner		Vapor Degreaser		Conveyorized Degreaser	
	A	B	A	B	A	B
Control devices						
Cover or enclosed design	X	X	X	X	X	X
Drainage facility	X	X	X			X
Water cover, refrigerated chiller, carbon adsorption or high freeboard[b]		X		X		X
Solid, fluid spray stream[c]		X		X		
Safety switches and thermostats				X		X
Emission reduction from control devices (%)	13-38	NA[d]	20-40	30-60		40-60
Operating procedures						
Proper use of equipment	X	X	X	X	X	X
Waste solvent reclamation	X	X	X	X	X	X
Reduced exhaust ventilation			X	X	X	X
Reduced conveyor or entry speed			X	X	X	X
Emission reduction from operating procedures (%)	15-45	NA[d]	15-35	20-40	20-30	20-30
Total emission reduction (%)	28-83[e]	55-69[f]	30-60	45-75	20-30	50-70

[a] Reference 2. Ranges of emission reduction present poor to excellent compliance. X indicates devices or procedures that will produce the given reductions. Letters A and B indicate different control device circumstances. See Appendix B of Reference 2.
[b] Only one of these major control devices would be used in any degreasing system. Cold cleaner system B could employ any of them. Vapor degreaser system B could employ any except water cover. Conveyorized degreaser system B could employ any except water cover and high freeboard.
[c] If agitation by spraying is used, the spray should not be a shower type.
[d] Breakout between control equipment and operating procedures is not available.
[e] A manual or mechanically assisted cover would contribute 6 - 18% reduction; draining parts 15 seconds within the degreaser, 7 - 20%; and storing waste solvent in containers, an additional 15 - 45%.
[f] Percentages represent average compliance.

As with cold cleaning, open top vapor degreasing emissions relate heavily to proper operating methods. Most emissions are due to (6) diffusion and convection, which can be reduced by using an automated cover, by using a manual cover regularly, by spraying below the vapor level, by optimizing work loads, or by using a refrigerated freeboard chiller (for which a carbon adsorption unit would be substituted on larger units). Safety switches and thermostats that prevent emissions during malfunctions and abnormal operation also reduce diffusion and convection of the vaporized solvent. Additional sources of emissions are solvent carryout, exhaust systems, and waste solvent evaporation. Carryout is directly affected by the size and shape of the workload, by racking of parts, and by cleaning and drying time. Exhaust emissions can be nearly eliminated by a carbon adsorber that collects the solvent vapors for reuse. Waste solvent evaporation is not so much a problem with vapor degreasers as it is with cold cleaners, because the halogenated solvents used are often distilled and recycled by solvent recovery systems.

Because of their large workload capacity and the fact that they are usually enclosed, conveyorized degreasers emit less solvent per part cleaned than do either of the other 2 types of degreaser. More so than operating practices, design and adjustment are major factors affecting emissions, the main source of which is carryout of vapor and liquid solvents.

References For Section 4.6

1. P. J. Marn, *et al.*, *Source Assessment: Solvent Evaporation — Degreasing,* EPA Contract No. 68-02-1874, Monsanto Research Corporation, Dayton, OH, January 1977.

2. Jeffrey Shumaker, *Control Of Volatile Organic Emissions From Solvent Metal Cleaning*, EPA-450/2-77-022, U. S. Environmental Protection Agency, Research Triangle Park, NC, November 1977.

3. W. H. Lamason, "Technical Discussion Of Per Capita Emission Factors For Several Area Sources Of Volatile Organic Compounds", Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 15, 1981, unpublished.

4. K. S. Suprenant and D. W. Richards, *Study To Support New Source Performance Standards For Solvent Metal Cleaning Operations*, EPA Contract No. 68-02-1329, Dow Chemical Company, Midland, MI, June 1976.